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I-CNSS

INTEGRATED COMMUNICATION NAVIGATION AND SURVEILLANCE SYSTEM

This Technical Specification Part II Safety Assessment Report is part of a project that has received funding from the SESAR3 Joint Undertaking under grant agreement No 874478 under European Union's Horizon 2020 research and innovation programme.

Abstract

The Safety Assessment Report (SAR) represents Part II of the TS/IRS document and presents the assurance that the Safety Requirements for the TRL2-TRL6 phases are complete, correct, and realistic, thereby providing all material to adequately support the PJ14-W2-79a GAST D Extended Scope Solution TS/IRS Part I.

The GAST D Extended Scope covers GAST D Ground Station operation in challenging environments, more specifically operating in geographical regions that can experience adverse ionosphere conditions and operating in airport environments subject to RFI interference impacting GBAS GS GNSS antenna reception.

The safety assessment activity reviewed the SESAR 1 15.3.6 deliverable D33 OFA GBAS CAT III L1 Updated Safety Assessment Report (SAR) Ed 00.02.02. The objective was to assess whether D33 covers the wave 2 GAST D Extended Scope and, based on the gap analysis, update or complete the safety assessment of the GAST D technological solution for the intended operational use cases defined in D33.

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1 Executive Summary

This document contains the results of the supplemental Safety Assessment for the Technological Solution PJ14-W2-79a GAST D Extended Scope. The GAST D Extended Scope covers GAST D Ground Station operation in challenging environments, more specifically operating in geographical regions that can experience adverse ionosphere conditions and operating in airport environments subject to RFI interference impacting GBAS GS GNSS antenna reception.

The safety assessment activity reviewed the SESAR 1 15.3.6 deliverable D33 OFA GBAS CAT III L1 Updated Safety Assessment Report (SAR) Ed 00.02.02. The objective was to assess whether D33 covers the wave 2 GAST D Extended Scope and, based on the gap analysis, update or complete the safety assessment of the GAST D technological solution for the intended operational use cases defined in D33.

The safety assessment gap analysis relies on the systematic ionosphere and RFI threat hazard identification that was performed for D33 in SESAR 1. Safety criteria, objectives, safety requirements, assumptions, limitations, and recommendations were reviewed, and several updates are proposed. The full safety assessment framework as provided in the SESAR safety reference material was not employed.

The Safety Assessment Report (SAR) represents Part II of the TS/IRS document and presents the assurance that the Safety Requirements for the TRL2-TRL6 phases are complete, correct, and realistic, thereby providing all material to adequately support the PJ14-W2-79a GAST D Extended Scope Solution TS/IRS Part I.

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2 Introduction

2.1 Background

The nominal GAST D solution was developed to TRL6 in SESAR 1 to support runway operations aiming to increase capacity in terms of runway throughput, enhance predictability at the airport through improvements to all aspects of runway operations, and enable enhanced approach procedures. The SESAR 1 deliverable D33 OFA Updated Safety Assessment addresses the Operational Improvement AO-0505-A Improved Low Visibility Runway Operations using GBAS CAT II/III for precision approaches based on GPS L1 addressed in Operational Focus Area (OFA) 01.01.01 LVP using GBAS.

It was identified at the end of SESAR 1 that GAST D Ground Station operating in the following challenging environments required further study:

- adverse atmosphere conditions (severe ionosphere gradients, scintillation) that are typical of equatorial and Nordic latitudes
- radio frequency interference threat scenarios.

These two research areas have been the focus of SESAR 2020 wave 1 PJ14-03-01 (targetted TRL4) and wave 2 PJ14-W2-79a (targetting TRL6) solutions. The goal has been to characterize the threats, study measures to detect and mitigate the impact of the threats and verify the performance of the GAST D Ground Station under these conditions. In the area of RFI, only unintentional RFI threats to the GAST D Ground Station have been studied in wave 2.

This SESAR 2020 wave 2 Safety Assessment Report builds upon the work carried out in the SESAR 1 deliverable D33 [1]. A screening/gap analysis assessed which parts of SESAR 1 D33 OFA Updated Safety Assessment related to the abnormal operational conditions iono and RFI that still are applicable and which parts needed to be updated or deleted.

Applicable ICAO and EUROCAE standards have been published in new revisions since D33 was issued in 2016. The gap analysis also identifies the changes in the standards that necessitate an update of D33 safety assessment and proposes suitable modifications.

2.2 General Approach to Safety Assessment

The SESAR 1 deliverable D33 OFA GBAS CAT III L1 Updated Safety Assessment Report (SAR) Ed 00.02.02 is the starting point for the safety assessment carried out within wave 2 PJ14-W2-79a GAST D Extended Scope.

The safety assessment activity is carried out in form of a gap analysis, reviewing the SESAR 1 15.3.6 deliverable with the objective to identify any gaps or modifications in the existing safety assessment when considering:

- The ionosphere and RFI threats that are studied in PJ14-W2-79a GAST D Extended Scope
- revisions of applicable ICAO and EUROCAE standards that have taken place since 2016.

The safety assessment approach that is outlined in SESAR Safety Reference Material [2] was employed when D33 was first developed. Within the scope of this gap analysis, the analysis in D33 is amended. The SESAR 1 safety assessment was carried out at operational level and considered both the success-based and failure-based SRM assessment approach. This wave 2 SAR considers the SESAR 1 safety assessment, in terms of GAST D concept, operational scenarios, and performed Functional Hazard Analysis (leading to identification of threats), to be complete and still applicable. The two abnormal operating conditions (adverse atmosphere conditions and ground segment unintentional RFI threat) were identified and analysed in SESAR 1. However, mitigation and performance validations related to the two challenging operating conditions listed above needed further study. The SESAR 2020 PJ14 GAST D Extended scope activities do not introduce any fundamental change in the GAST D operational concept. The focus has been improving and validating the GAST D Ground Station monitors for handling operation during abnormal atmosphere conditions or when subject to unintentional RFI occurrences impacting ground station GNSS reception at the airport.

Safety criteria, objectives, safety requirements, assumptions, limitations, and recommendations were reviewed, and updates are proposed, where necessary.

2.3 Scope of the Safety Assessment

The safety assessment scope is limited to the work covered by PJ14-W2-79a solution. That is, the GAST D ground station operating in the following adverse environments:

- in geographical regions prone to severe ionosphere gradients and scintillation
- in airport environments subject to unintentional RFI.

In addition, the applicable ICAO and EUROCAE standards are checked to identify updates to the standards that may have impact on the work done in SESAR 1 D33.

2.4 Layout of the Document

The document structure has been modified to facilitate documenting the outcome of the D33 OFA SAR gap analysis that was carried out. The full SESAR 2020 Safety Reference Material approach has not been followed.

Section 2 Introduction provides a summary of the background, scope, and layout of the safety assessment report

Section 3 describes the safety assessment gap analysis approach

Section 4 summarizes the outcome of the gap analysis and proposes update of D33 OFA SAR, where required. This section refers to the D33 section headings. The SESAR 1 deliverable D33 itself is not updated to a new revision.

Section 5 indicates the impact on TS/IRS Part I

Section 6 Acronyms and Terminology

Section 7 References

Appendix A Update of SESAR 1 D33

3 Setting the Scene of the Safety Assessment

3.1 Concept overview and scope of the change

3.1.1 Technological change: GBAS GAST D Concept

Concept description

GBAS Approach Service Types (GAST) are defined as the matched sets of airborne and ground performance and functional requirements that are intended to be used in concert to provide approach guidance with quantifiable performance. GAST D has been introduced to support landing operations in lower than CAT I visibility conditions including Category III operations.
With GAST D concept, the ground subsystem protects the aircraft in the range domain by monitoring each GPS measurement received on L1 frequency only against an acceptable error limit. It then transfers parameters through the VHF Data Broadcast (VDB) in order that the aircraft compute protection level to protect the aircraft in the position domain. The aircraft receives the integrity alerts with regard to exceeded protection levels, but the airborne receiver has now the responsibility to select a satellite geometry subset that is adapted to its performance – this is called geometry screening. The geometry screening is the process of satellite selection according to pre-defined criteria linked to aircraft capabilities. An overview of the GAST D concept is provided in GBAS CAT II-III L1 CONOPS [3] while more details can be found in the ICAO GAST D concept paper [4] and the ICAO SARPs GAST D baseline **Error! Reference source not found.**.

The aerodrome infrastructure and basic air traffic service provision requirements are unchanged compared to the baseline situation if GAST D concept is used like ILS CAT III. However, some operational aspects associated to the GBAS CAT III operation are impacted (e.g., procedure design and publication, maintenance, controller, and flight crew procedures). Whereas one ILS System must be implemented per runway end, GAST D can support CAT III operations for multiple or all runway ends of the aerodrome.

The GAST D concept replaces the ILS CAT III concept for approach and landing operations including the rollout phase and relies on:

- Ground Subsystem
- Aircraft Subsystem
- GNSS Satellites Subsystem based on GPS L1 frequency only

An important aspect of GAST D concept is the role played by the available performance of each aircraft. Indeed, Flight Technical Error (FTE) of a given aircraft type provides the aircraft capability, thus leading to identify the resulting margin for Navigation System Error (NSE) allocation to meet Cat III requirements. This means that the ground monitors thresholds are dependent of the worst aircraft FTE targeted to conduct this type of operation. It has thus been identified that FTE of aircraft targeted for Cat III must be communicated at ICAO level and stay within an acceptable range for feasibility purposes.

SESAR 1 scope

The GAST D technological solution for nominal operating conditions was developed to TRL6.

3.1.2 Scope of SESAR 2020 GAST D Extended Scope Safety Assessment

Wave 1 and wave 2 scope

Focus on the challenging operating environments identified in SESAR 1:

Adverse atmosphere conditions

GBAS provides approach, landing, rollout, and take-off guidance, similar to an ILS. The performance requirements (integrity and continuity requirements) imposed on GBAS by ICAO, are at a similar level as those applicable to ILS.

The integrity of the data that the GAST D ground station sends to the aircraft over the VDB link are dependent on the correct functioning and performance of the Ground Subsystem internal processing and monitors. Loss of the integrity can lead to catastrophic events. The ICAO SARPS integrity requirements are not to be compromised. Thus, detecting and mitigating for adverse operating conditions is paramount. If the integrity of the transmitted GAST D data cannot be guaranteed, the GAST D Ground Station shall cease transmission.

PJ14-W2-79a seeks to improve detection algorithms and performance of the monitors used to handle adverse atmosphere conditions, covering severe troposphere, ionosphere, and scintillation conditions. This type of monitor is cited as mitigation measure for reducing safety risk in SESAR 1 SAR [5]. The performance of Ionosphere Gradient Monitor is a planned validation exercise in PJ14-W2-79a TVALP.

Radio Frequency Interference

Unintentional RFI impacting the GPS L1 signal reception can lead to loss of GBAS guidance during the approach when interference signals are encountered and is considered a continuity event. Loss of GBAS guidance will typically lead to the aircraft executing a go-around.

PJ14-03-01 focussed on determining achievable performance for detection and mitigation strategies to improve robustness of GAST D Ground Subsystem towards GNSS vulnerabilities to RFI. PJ14-W2-79a builds onto that work, and focusses on characterizing the RFI environment in general, and also contributes, on conceptual level, to RFI mitigation within the GAST F concept.

The following aspects are out of scope for this safety assessment gap analysis:

- VDB RFI impact
- Intentional RFI.

3.2 Stakeholders' expected benefits with potential Safety impact

See D9.1.110 PJ14-W2-79a GAST D Extended Scope TS/IRS Part I.

3.3 Intended Operational use of the Technological Concept

See D9.1.110 PJ14-W2-79a GAST D Extended Scope TS/IRS Part I.

3.4 Relevant applicable standards

- ICAO Annex 10, Vol. I, SARPS, Amendment 92, November 2020
- ICAO Doc 8071 Vol. II
- EUROCAE ED-114B MOPS for GBAS ground systems to support precision approach and landing

3.5 Overview of activities performed

A workshop carried out performing a gap analysis focusing on aspects related to the GAST D Extended Scope that is addressed in SESAR 2020 PJ14-W2-79a (and its predecessor PJ14-03-01 achieving TRL4). PJ14-W2-79a solution partners together with PJ19 Safety expert (EUROCONTROL) participated.

The participants of the workshop discussed successively the sections of SESAR 1 D33 GBAS CAT III L1 Safety Assessment, identifying the relevant work items that needed to be re-addressed with respect to the SESAR 2020 GAST D Extended Scope. A list of work items and proposed actions to close the work items were compiled.

3.6 Documenting the D33 Gap Analysis

In the next section, each item identified by the gap analysis workshop will be discussed and appropriate changes proposed. Reference to the relevant section in the SESAR 1 D33 will be made. The results of section **Error! Reference source not found.** will be summarized as an Update to SESAR 1 D33 OFA SAR in Appendix A.

3.7 Closing the Gap – identifying the items and proposing updates

As mentioned above, a workshop identified the elements of SESAR 1 D33 that needed to be considered in the light of the activities that have taken place since that report was issued. This section is organised in accordance with D33, more specifically identifying the sections and elements that should be reconsidered. It proposes rewording where relevant. The changes are summarized in Appendix A.

3.7.1 D33 Section 2.8.2 Table 4 Potential Mitigations of Abnormal Conditions

An inconsistency is identified between D33 section 3.4.1 Table 20 row 2 where integrity is mentioned and Table 4 in D33 section 2.8.2 where only continuity is listed.

Issue:
Assess whether Unintentional RFI could be considered an integrity event (instead of continuity event). Refer D33 §2.8.2 Table 4.

Resolution:
Unintentional RFI was studied in detail in PJ.14-03-01, and several hundred representative jammer characteristics were simulated in the lab to investigate the impact on GBAS performance in general. It was confirmed that the primary impact was on continuity (and availability). However, the focus of this activity was to investigate whether there was a performance impact *prior* to receivers losing lock, under increasing jammer levels. It was found that the jammers did increase the noise levels during this phase prior to receivers losing lock, with increasing Pseudorange noise as a result. It was found, however, that the increased noise was small, and that it was possible to overbound it, partly by increasing protection levels slightly in the nominal case, and partly by increasing the protection levels based on C/N0 effects that were found to characterize performance. This overbounding was found to be able to bound the effect of jammers, whilst being acceptable from an availability and continuity point of view. GBAS ground station built-in jamming detectors were developed to aid operator in identifying jamming incidents that are too low to cause any other observable effects on the GBAS signals, such as loss of lock of individual receivers, or total loss of continuity of the GBAS signal-in-space [5].

Based on this finding, that the impact on the pseudorange error was in the decimeter range and possible to overbound, it is proposed to keep continuity as the main effect in row 2 of D33 table 4 of section 2.8.2. To cover the gap identified by this finding, it is proposed to add the following text, as shown below.

Proposed new text as addendum to D33 (in blue):

2	Unintentional Interference (impacting GNSS and/or VDB) →specific to GBAS	The aircraft might loss the GBAS guidance (continuity event) during the approach when encountering the interference	Note that loss of continuity is considered the main effect of unintentional RFI. However, this relies on the assumption that the ground station is appropriately designed, in accordance with ED-114B 3.3.1.6 "Integrity in the Presence of Excessive Radio Frequency Interference". Preventive Mitigations: a) The proposal for mitigating the effects of the interference should rely on a combination of: • Siting restriction on the ground subsystem • State spectrum regulation, frequency management and enforcement of these regulation • Specific maintenance procedure as a prerequisite • Making the GBAS Ground Station, as well as airborne GNSS receivers robust against interference, See **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.** • Above preventive mitigations will be captured in SAR section **Error! Reference source not found.**

			b) For GBAS CAT III approach and landing: → Aircraft respects the lateral and vertical path of the published GBAS approach when interference signals are encountered or aircraft executes a safe go-around (SO#0315/ SAC#01) →Aircraft lands in the prescribed touch down zone when interference signals are encountered or aircraft executes a safe go-around (SO#0320/ SAC#04) → Successful Aircraft GBAS landing rollout when interference signals are encountered or aircraft executes a safe go-around (SO#0325/ SAC#04) c) For GBAS guided Take-Off: → Aircraft respects the lateral path for the guided take-off from the start of the take-off roll to the main wheel lift-off when interference signals are encountered or aircraft aborts safely the take-off. (SO#0405/ SAC#04). Corrective Mitigations: → Aircraft executes a missed approach in case of loss of GBAS continuity during a GBAS CAT III approach. The missed approach can be executed with the autopilot still engaged or manually. (SO#330/ SAC#01 and SAC#04). → Aircraft aborts the guided take-off in LVC in case of loss of GBAS continuity and impossibility to continue to monitor external visual cues (centerline lights) (SO#410/ SAC#04).

Table 1 Extract of D33 Table 4 – row 2 covering abnormal condition: unintentional interference

3.7.2 D33 Section 3.4.2.1 Table 21 Derivations of Safety Requirements by considering OSED potential mitigations

For reader convenience, the D33 Table 21 is inserted here. The items in the table that are subject to re-evaluation in this gap analysis are indicated in red font. Only two of the ten abnormal conditions in D33 Table 21 are relevant for the safety assessment gap analysis. The relevant abnormal conditions are:

- #1 Severe Ionospheric disturbances
- #2 Unintentional Interference

Updates to the tables are proposed in the following subsections 3.7.2.1 to 3.7.2.7.

In the following subsections, updated text is presented using strikethrough of text to be deleted and new text in blue font. The complete revised Table 21 is summarized in the Appendix A Update to D33.

Preventive mitigations for abnormal conditions	Safety Requirements for abnormal conditions
#1 Severe Ionospheric disturbances	
Monitoring in the ground subsystem	See SR200 (includes provisions on iono gradient monitors).
	REC#0020: Depending on ionospheric conditions, the risk of exposure to scintillations should be taken into account in the monitor design
	LIM#0006 The effect of tropospheric disturbances on iono monitoring is covered by a new ICAO SARPS Ionospheric Gradient Mitigation (IGM) requirement but validation/verification of this requirement is not yet finalized
	A#0240: In the ECAC zone, severe ionospheric gradients occur with a probability of 1E-05. Note: GAST D iono gradient monitoring is built upon assumptions about the frequency of occurrence of such phenomena. This "prior probability" may be different from one geographic region to another, but at least a worst-case assumption should be captured in operational safety assessments so that the ANSP may correlate it with local space weather measurements.
Monitoring in the airborne segment	See SR175 (includes provisions on airborne mitigation of iono anomalies).
Siting restriction on the ground subsystem	SR 500: The GAST-D Ground Station siting requirements shall include measures taking into account the effect of ionospheric disturbances. Technical traceability/comments: a. The maximum distance from GBAS reference point to any threshold served by the station shall be 5 km in order to mitigate ionospheric anomalies (from 15.03.06 D04 Req: [Iono1] and 15.3.6 GAST D Conops S4). Note: It has been proposed that the 5 km limitation be replaced by a limit to be determined per site/per manufacturer. This change was not validated and/or implemented at the moment of writing this report. b. Antenna separations shall be determined based on risk of correlated multipath, and the selected Ionospheric gradient monitoring scheme (from 15.03.06 D04 Siting Consideration Req [Iono2] and 15.3.6 GAST D Conops S7). c. Depending on selected ionospheric gradient monitoring scheme, the effective baselines shall be perpendicular to the worst-case wave front and thus aligned with the runway for which GAST D operation shall be performed (from 15.03.06 D04 Req [Iono3]).
	REC#0021: The stability of the antenna foundation should be considered with respect to the selected ionospheric gradient monitoring scheme.
	SR#503: The ANSP siting procedures shall include an analysis of distance of the GBAS reference point from threshold to verify that the ionospheric threat is mitigated.
A standard threat space which defines the range of ionospheric anomalies to which the user will be exposed	REC#0022: MET and AIS providers should undertake specific studies in order to assess the feasibility of space weather forecast integration into the NOTAM system or by providing directly to end-users "Extreme Space weather" alerts, to prevent usage of GBAS for Cat III operations in case of very large ionospheric storm.
Local ionospheric threat space assessment by ANSP	REC#034: It is recommended that a worst-case assumption on the frequency of iono gradients be defined by the GS manufacturer in order to permit local correlations by ANSPs
	SR#502: ANSPs shall perform local assessments on each GAST D implementation scenario to define the conditions under which the ECAC ionospheric threat space is realistic.

Preventive mitigations for abnormal conditions	Safety Requirements for abnormal conditions
#2 Unintentional Interference (impacting GNSS and/or VDB)	
Siting restriction on the ground subsystem	SR 505: Antenna height shall be determined on the basis of generic multipath considerations and risk of jamming and on-site activities Technical traceability/comments: 15.3.6 D04 - Integrity1
	SR 532: GAST-D Ground Station architecture and design shall take the risk of interference by GNSS repeaters and jammers into account, such that the Ground Station is robust against interference on a limited number of receivers.
	SR 533: GAST-D Ground Station site selection shall take the risk of RFI due to GNSS jammers and repeaters into account. Specifically: -Antennas shall be sited at as far as possible from public areas such as roads. A minimum siting distance from public roads shall be defined. -A minimum distance between the GBAS receivers and the areas where GNSS repeaters could be installed shall be defined by the ground station manufacturer and adopted, as far as possible, by the ANSP siting procedures. -Site PPD dampening verification studies shall be performed by the ANSP and the ground station manufacturer, if deemed necessary;
	SR 534: ANSP/Airport procedures shall include the development of additional mitigation methods, such as (for instance) barrier construction, use of additional standby reference receivers or reference receiver relocation, in case interference sources cannot be removed.
	REC#0039: It is recommended that further research is performed on how the GAST D ground station architecture may accommodate additional standby reference receiver antennas.
	SR 536: GAST D ground station implementation procedures shall never use siting as sole PPD mitigation measure.
	REC#0025: Local airport development plans should be considered in the development of local GAST D GS siting procedures.
	REC#0036: It is recommended that further research is performed on the use of active antennas with null steering in GAST D ground stations
	REC#0037: Studies should be performed by each State on the most locally appropriate GNSS band interference monitoring scheme.
	REC#0038: It is recommended to develop low cost, consumer grade technical solutions for detecting jammers which should be installed in monitoring systems.
	A#0241：PPDs are assumed to use a chirp waveform. PPD power is assumed to be within 0.1 mW and 1 W (maximum recorded PPD power)
	I#005: It is considered impossible to test all possible current and future PPD implementations – basic research is still needed on the possibility to bound impacts of PPDs.
State spectrum regulation, frequency management and enforcement of these regulation	A#0080: Frequency coordination activities are performed by the ANSPs to avoid radio frequency interference in the NAV frequency range (108 – 118 MHz), including ILS/GBAS interference.
	SR 510: Regulatory material in line with the applicable standards shall be defined and applied to ensure the operation of aeronautical equipment is free from radio frequency interference in the ARNS frequency range

Preventive mitigations for abnormal conditions	Safety Requirements for abnormal conditions
	Technical traceability/comments: Includes GNSS repeater and pseudolite regulations / standards.
	SR 515: The GBAS service provider shall define interference monitoring and control procedures, such that: a. The interference environment at the reference receivers' sites is proven to be lower than the nominal interference environment/ repeater power recommendation level, before the start of operations, and b. The GBAS GAST-D service is cancelled whenever the interference environment at the reference receivers' sites is higher than the nominal interference environment / the repeater power recommendation level and c. The interference environment considers both the airport environment and the final part of the aircraft trajectories. Note: Technical traceability/comments: The nominal interference environment is given by the interference threshold masks in Appendix E of ED-114A and other standards defining boundaries for acceptable RFI levels (e.g., repeaters)
	SR 520: Interference assessment shall be conducted by means of: a. Ground tests shall be conducted during siting of the ground subsystem to verify the level of RFI complies with ED-114A App. E and the applicable repeater power recommendation levels b. Flight tests during flight check of all GBAS approaches supported by a GBAS ground facility Technical traceability/comments: An appropriate ground test methodology is described in ED114A chapter 5.15.6.1. An appropriate flight test methodology is described in ED114A chapter 5.16.3.
	I#006: Regulatory requirements to enforce ETSI recommendation implementation are not in place. Some important parameters on ground and airborne component side to be taken into consideration for repeater protection could be problematic due to insufficient standardization (e.g., receiver sensitivity or correlator spacing).
	A#0085: GBAS GAST D equipment always contains RFI mitigations (e.g., an RFI monitor).
Making GNSS receivers (ground and airborne) robust against interference	See SR200 (includes provisions on robustness against interference).
	REC#0026: In order to support problem investigation and maintenance, the GBAS ground equipment should output the signal-to-noise ratio for each satellite.
	I#007: There is a need to further analyse the dynamic response of GAST-D aircraft subsystem in presence of GNSS repeaters, but it is extremely difficult to make deterministic assumptions about airborne subsystem behaviour. There is also a need to explain the order of magnitude of the probability of occurrence of airborne position errors in presence of GNSS repeaters. It is recommended to further analyse and (if possible) quantify the following statements: a. The main perturbation was identified during a take-off manoeuver and not in the more constraining landing phase. This circumstance could be considered as a risk mitigation. The distance between A/C and GNSS repeater is almost proportional to the measurable error effect on the airborne subsystem. The safety risk can be bounded by the definition of a critical area, permitting the operation of GNSS repeaters in the near airport environment.
	REC#0040: It is recommended to study the feasibility of separating GPS antenna positions for the different installed airborne GNSS receivers. The antenna separation increase should be enough to reduce the probability of identical erroneous behaviour in face of GNSS repeaters, and to improve the probability to detect an error via the guidance system architecture.

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Preventive mitigations for abnormal conditions	Safety Requirements for abnormal conditions
	REC#0041: It is recommended to study the feasibility of refining the GNSS repeater interference monitoring means available for the airborne component implementation, to be protected at least against a part of the threat.
Updated maintenance procedures	SR 525 If interference is confirmed, maintenance procedures shall ensure that the approach procedure be removed from operational status pending corrective action and appropriate authorities notified. Maintenance task levels A/B shall be assigned depending on the impact of the interference over the continuity and/or integrity of the service performance of the Ground Subsystem.
	SR 530: Airport maintenance procedures shall include the creation (if needed), or the maintenance and repairing (if they exist) of fencing/ barriers designed to block/dampen interfering signals
	SR 531: If interference is suspected, maintenance procedures shall define the conditions of investigation efforts and pre-commissioning surveys of the interference environment. Maintenance task levels A/B shall be assigned depending on the impact of the interference over the continuity and/or integrity of the service performance of the Ground Subsystem. Note: The suspected area should be probed, and spectrum analysis accomplished to define its geographical extent; GNSS and GBAS parameters such as signal/noise ratio, lateral and vertical protection levels, and DOP should be documented.
	REC#028: Airport maintenance procedures should include the development of additional mitigation methods, such as barrier construction or reference receiver relocation, in case interference sources cannot be removed.
#3 + #7: Severe weather conditions	
No changes – table rows not copied from D33	
#4: Over flight disruption of GBAS ground subsystem or Reference Receiver antenna masking (Signal blockage)	
No changes – table rows not copied from D33	
#5: Excessive Multipath affecting GNSS at ground level	
No changes – table rows not copied from D33	
#6: Wrong Arrival Sequence Manager sequencing for optimised operation conducted in mixed GBAS/ILS equipage	
No changes – table rows not copied from D33	
# 8 GPS constellation failure/degradation leading to GPS SIS loss	
No changes – table rows not copied from D33	
# 9 Satellite phase jumps	
No changes – table rows not copied from D33	
# 10 SV manoeuvres	
No changes – table rows not copied from D33	

Table 2 Red text identifies D33 Table 21 items that require revised safety assessment

3.7.2.1 REC#0020

This recommendation is phrased as:

REC#0020: "Depending on ionospheric conditions, the risk of exposure to scintillations should be taken into account in the monitor design".

The technical validation of this recommendation has progressed within the scope of PJ14-W2-79. However, this recommendation is still valid, and therefore, no change is proposed.

3.7.2.2 LIM#0006

This limitation is phrased as:

LIM#0006: The effect of tropospheric disturbances on iono monitoring is covered by a new ICAO SARPS Ionospheric Gradient Mitigation (IGM) requirement, but validation/verification of this requirement is not yet finalized

It is proposed to delete this limitation as the new ionospheric gradient has been validated in the context of PJ14-W2-79a.

The limitation related to validation of tropospheric influence on the ionospheric gradient monitor is also mentioned in the executive summary. In Appendix A, it is proposed to delete this limitation. The text used in the executive summary is also found in the conclusion of D33. A change is proposed to this text in section 3.7.3.

Also, a need was identified to add a requirement similar to SR502, but related to tropospheric disturbances, requiring ANSPs to establish a tropospheric model in case the ground station ionospheric monitoring scheme relies on a tropospheric threat model.

SR#502: ANSPs shall perform local assessments on each GAST D implementation scenario to define the conditions under which the ECAC ionospheric threat space is realistic.

A new requirement is proposed for D33 Appendix B Consolidated List of Safety Requirements:

SR 455 [Engineering Activity] [CAT III APP; Guided T/O]	If the Ground Subsystem monitoring concept for ionospheric monitoring makes assumptions on the tropospheric threat space, the ANSP shall perform a local assessment to establish a tropospheric characterization	SO#0300 SO#0305 SO#0310 SO#0400

Also, this requires an amendment to table 21 in D33 section 3.4.2.1:

Local ionospheric threat space assessment by ANSP	REC#034: It is recommended that a worst-case assumption on the frequency of iono gradients be defined by the GS manufacturer in order to permit local correlations by ANSPs
	SR#502: ANSPs shall perform local assessments on each GAST D implementation scenario to define the conditions under which the ECAC ionospheric threat space is realistic.
	SR#455: If the Ground Subsystem monitoring concept for ionospheric monitoring makes assumptions on the tropospheric threat space, the ANSP shall perform a local assessment to establish a tropospheric characterization

3.7.2.3 A#0240

This assumption is phrased as:

A#0240: In the ECAC zone, severe ionospheric gradients occur with a probability of 1E-05.

D9.3.120 European ionosphere threat and mitigation [7] confirms that this assumption is valid for most areas. The exception is the Canary Islands.

When computing the prior probability for exposure to an ionospheric gradient, it is necessary to consider a longer exposure time than just the landing phase (15s), as is done for other faults. In the case of ionospheric gradients, the airborne receiver is exposed during the entire approach since exposure to ionospheric gradients early on the approach may cause filter build-up and therefore cause pseudorange deviations in a later phase of the approach/landing. Therefore, we have considered the entire approach (150s) as exposure time when assessing the prior probability for being exposed to an ionospheric gradient.

For the Canary Islands, 38.6 true gradients per station pair have been detected over a period of a solar cycle (11 years). This corresponds to a probability per 150 s of:

$$P_{prior} = \frac{38.6\ gradients/station\ pair \times 150s}{11 \times 8760h \times 3600}$$

$$P_{prior} = 1.7 \times 10^{-5}$$

The Canary Islands are at a latitude of approximately 29˚ southwards. Three new clusters have been added recently that are further south of those that have already been included in the study for a while. There is currently not enough data from these to fully conclude whether they are within the 1E-05/landing probability or not. The southernmost clusters that have substantial data are Madrid and Corsica. They are well within the 1E-05/landing probability, at latitudes slightly north of 40˚. Between 30˚ and 40˚, there is therefore not enough data to conclude whether the prior assumption of 1E-05/landing holds. It is therefore proposed to change A#0240 as follows:

A#0240: North of N40˚ in the ECAC zone, severe ionospheric gradients can be assumed to occur with a probability of less than 1E-05. Between N40˚ and N26˚ in the ECAC zone, severe ionospheric gradients can be assumed to occur with a probability of less than 1E-04.

This is conservative and is expected to bound the prior in the years to come.

3.7.2.4 REC034

This recommendation is phrased as:

REC#034: It is recommended that a worst-case assumption on the frequency of iono gradients be defined by the GS manufacturer in order to permit local correlations by ANSPs.

It was noted in the safety workshop that this recommendation only applies when a prior probability of ionospheric gradients lower than 1 is assumed in the Ground Subsystem monitor design and that this needs clarification. Still, it is proposed to keep this recommendation as is, as it is useful to state the prior assumed in any case. It could be risky for the ANSP to assume that if nothing is mentioned regarding an assumption on prior probability of an ionospheric gradient, this implies that the ground subsystem design assumes a prior of 1.

3.7.2.5 SR 500

The safety requirement is phrased as:

SR500: The GAST-D Ground Station siting requirements shall include measures taking into account the effect of ionospheric disturbances.

The validation of the SARPs, and changes implemented later through State Letter 2021_041, made it clear that a sharp, absolute cut-off at 5 km or similar was not beneficial. Also, the validation that took place at the final stages of issuing the GAST D SARPs, showed that ionospheric gradients from all directions need to be detected. 15.03.06 D04 Requirement [Iono3] [8] was therefore incomplete.

The proposed changes to the table entry are (in blue font):

Technical traceability/comments:

a. ~~The maximum distance from GBAS reference point to any threshold served by the station shall be 5 km in order to mitigate ionospheric anomalies (from 15.03.06 D04 Req: [Iono1] and 15.3.6 GAST D Conops S4). Note: It has been proposed that the 5 km limitation be replaced by a limit to be determined per site/per manufacturer. This change was not validated and/or implemented at the moment of writing this report.~~ A GAST D ground subsystem shall transmit parameters MEIG and YEIG overbounding the worst case residual ionospheric range error decorrelating with distance, up to a distance specified as the maximum distance at which the specific ground subsystem can serve CAT III LTPs. The Ground Subsystem monitor design shall be optimized, targeting a maximum EIG (residual ionospheric range error) of 2.75 m 5 km from the ground facility.

b. Antenna separations shall be determined based on risk of correlated multipath, and the selected Ionospheric gradient monitoring scheme (from 15.03.06 D04 Siting Consideration Req [Iono2] and 15.3.6 GAST D Conops S7).

c. Depending on selected ionospheric gradient monitoring scheme, the effective baselines shall be perpendicular to the worst-case wave front and thus, in order to detect gradients from all directions, must have projected baselines both aligned with, and perpendicular to, CAT III runways. ~~aligned with the runway for which GAST D operation shall be performed~~ (from 15.03.06 D04 Req [Iono3]).

3.7.2.6 A#0241

The assumption is phrased as:

A#0241 is phrased as: PPDs are assumed to use a chirp waveform. PPD power is assumed to be within 0.1 mW and 1 W (maximum recorded PPD power)

It is proposed to keep this assumption as is. The output power determines at which distance the jammer causes the receiver to fail tracking. Higher power will therefore cause loss of continuity at a longer distance. The output power of jammers is outside of our control, jammers are illegal already, so there is no point in determining a "harmless" level of jammer power. The purpose of the activity in SESAR 2020 has been:

- To gather data about jamming conditions
- To ensure the ground station is as robust as possible, should it be subject to jamming.

3.7.2.7 SR200

The safety requirement SR 200 considers compliance with ICAO SARPs. Original text:

SR200: The GAST-D Ground Subsystem shall be compliant with ICAO Annex 10 SARPS amended as per ICAO NSP proposals issued in 2015

To take into account the work that has taken place under PJ14-03-01 and PJ14-W2-79 in order to better accommodate operation under challenging ionospheric conditions from a standardisation point of view, SR200 should be updated. In State Letter 2021-041, requirement 3.6.7.3.4 has been updated to allow operation also outside the distance where the potential worst case residual ionospheric range error exceeds 2.75m, as long as the E_{IG} transmitted by the ground subsystem bounds the error, so that the airborne geometry screening can ensure integrity is maintained. The change should be as shown below.

SR 200 [GAST-D GS] [CAT III APP and Guided T/O]	The GAST-D Ground Subsystem shall be compliant with ICAO Annex 10 SARPS amended as per ICAO NSP proposals issued in 2021~~15~~

3.7.3 D33 Section 4 Conclusions

The conclusions in Section 4 of D33 are updated with latest status taking into account the validation results from solution PJ14-W2-79a, see Appendix A.

The limitation related to validation of tropospheric influence on ionospheric monitoring is repeated both in the Conclusion section of D33, and in the Executive Summary. It is proposed to edit D33 as follows:

~~Several limitations have been identified and the main ones are relative to:~~ The main outstanding limitation, not finally addressed and concluded within the scope of the SESAR R&D projects, is the ~~The~~ suitability of CAT II only aircraft for GAST D which was not fully shown in SESAR 1 and which needs to be addressed by SESAR 2020.

- ~~The effect of tropospheric disturbances on ionospheric monitoring is covered by a new Ionospheric Gradient Mitigation (IGM) requirement but validation/verification of this requirement was not finalized in SESAR 1.~~

3.7.4 D33 Appendix G Skills and competences for maintenance personnel working on GBAS

All references to maintenance personnel qualification and training requirements made by D33 Appendix G to Regulation (EU) 1035/2011, which is currently repealed, should now be made with respect to Regulation (EU) 2017/373 (in particular, to Annex XIII) and their associated AMCs and GMs.

The new regulatory provisions, however, have not been considered incompatible with the maintenance task levels A/B/C defined by the EUROCONTROL guidance document EAM 5 / GUI 3 to ESARR 5. This document can therefore be considered as an additional guidance material to the GMs defined by EASA. EAM 5 / GUI 3 was used by D33 to characterise the different maintenance tasks according to its criticality. In case different maintenance task level classifications were used, their equivalence with respect to EAM 5 / GUI 3 would need to be proven.

Two safety requirements SR525 and SR531 in Table 2 have been modified to address maintenance task level classification.

3.8 Conclusions

The safety assessment activity reviewed the SESAR 1 15.3.6 deliverable D33 OFA GBAS CAT III L1 SAR [1] with the objective to identify required changes that needed to be addressed to cover the safety aspects of GAST D ground system operating under abnormal conditions. The safety assessment gap analysis relied on the systematic ionosphere and RFI threat hazard identification that was performed for D33 in SESAR 1. Safety criteria, objectives, safety requirements, assumptions, limitations, and recommendations related to adverse atmosphere and unintentional RFI threat scenarios were reviewed, and several updates are proposed. One new safety requirement, SR #455, was added. This requirement deals with the need for carrying out a local assessment of the tropospheric threat if the Ground Subsystem monitoring concept for ionospheric monitoring makes assumptions on the tropospheric threat model. All proposed updates are discussed in section 3.7 and summarized in Appendix A. The full safety assessment framework as provided in the SESAR safety reference material was not employed.

The Safety Assessment Report (SAR) represents Part II of the TS/IRS document and presents the assurance that the Safety Requirements for the TRL2-TRL6 phases are complete, correct, and realistic, thereby providing all material to adequately support the PJ14-W2-79a GAST D Extended Scope Solution TS/IRS Part I.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

4 Safe Design of the Technical System

4.1 Overview of activities performed

Safe design of the technical system was addressed in SESAR 1 in the deliverable SESAR 1 15.03.06 D04 Ground Architecture and Airport Installation [8].

This is not re-visited in SESAR 2020 wave 2 PJ14-W2-79a. The remaining section 5 subsections have therefore been removed.

EUROPEAN PARTNERSHIP

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5 Acronyms and Terminology

Acronym	Definition
AIS	Aeronautical Information Service
ANSP	Air Navigation Service Provider
ASS or A#	Assumption
CONOPS	Concept of Operation
DOP	Dilution Of Precision
ECAC	European Civil Aviation Conference
EUROCAE	European Organisation for Civil Aviation Equipment
FHA	Functional Hazard Assessment
FTE	Flight Technical Error
GAST D	GBAS Approach Service Type D
GBAS	Ground Based Augmentation System
GNSS	Global Navigation Satellite System
GPS	Global Positioning Service
I or I#	Information or Issue
ICAO	International Civil Aviation Organization
IGM	Ionospheric Gradient Mitigation
ILS	Instrument Landing System
LIM or LIM#	Limitation
LTP	Landing Threshold Point
NSP	(ICAO) Navigation Systems Panel
OFA	Operational Focus Area
PPD	Privacy Protection Devices
REC or REC#	Recommendation

RFI	Radio Frequency Interference
SAC or SAC#	Safety Criteria
SAR	Safety Assessment Report
SARPs	Standards and Recommended Practices
SESAR	Single European Sky ATM Research Programme
SIS	Signal In Space
SO or SO#	Safety Objective
SR or SR#	Safety Requirement
SRM	Safety Reference Material
SJU	SESAR Joint Undertaking (Agency of the European Commission)
T/O	Take-Off
TRL	Technical Readiness Level
TS/IRS	Technical Specification /Interface Requirement Specification
VDB	VHF Data Broadcast
VHF	Very High Frequency

Table 3: Acronyms

6 References

[1] SESAR 1 15.03.06 D33 OFA 01.01.01 GBAS CAT III L1 Updated Safety Assessment Report and security considerations, ed. 00.02.02, Aug 2016

[2] SESAR Safety Reference Material from SESAR 1 – SESAR P16.06.01, Task T16.06.01-006, SESAR Safety Reference Material, Edition 00.03.01, 09th March 2015 and SESAR P16.06.01, Task T16.06.01-006, Guidance to Apply the SESAR Safety Reference Material, Edition 00.03.00, 09th May 2016

[3] SESAR 1 15.3.6 D20-002 Final GBAS CONOPS including CAT II/III L1 specificities Ed. 00.01.00, July 2012

[4] ICAO NSP3 Conceptual Framework for the Proposal for GBAS to support CAT III Operations, December 2016

[5] ICAO International Standards and Recommended Practices – Aeronautical Telecommunications Annex 10 to the Convention on International Civil Aviation, Volume I (Radio Navigation Aids), including all Amendments up to Amendment 93 (November 2023).

[6] SESAR 2020 W1 PJ.14-03-01 D8.4.010 TVALP TRL4 GAST D Extended Scope, ed.01.00.00, December 2018

[7] SESAR 2020 PJ14-W2-79a D9.3.120 European ionosphere threat and mitigation, ed.00.01.02, March 2022

[8] SESAR 1 15.03.06 D04 Ground Architecture and Airport Installation, ed.00.01.00, March 2013

Appendix A Update of SESAR 1 D33 OFA 01.01.01 GBAS CAT III L1 Updated Safety Assessment Report

The table below contains texts proposals for revision of the SESAR 1 D33 Safety Assessment Report [1]. The page, paragraph and amended paragraph text, table text, or figure is stated. For text changes, the modification is indicated using the blue font color.

<table>
<tr><th>Page</th><th>Para.</th><th>Amendment Text</th></tr>
<tr><td></td><td>3.2.3

Table 12</td><td>The SR 200 in Table 12 shall be updated as follows:
<table>
<tr><td rowspan="4">SO#0060 The aircraft GBAS Total System error (TSE) shall be equivalent or better than ILS CAT III TSE</td><td>SR 200: The GAST-D Ground Subsystem shall be compliant with ICAO Annex 10 SARPS amended as per ICAO NSP proposals issued in 2021.</td><td>GAST-D Ground Subsystem → GAST-D Aircraft Subsystem / 17(GBAS Messages)</td></tr>
<tr><td>SR 205: GBAS CAT III Flight Inspection shall be conducted in accordance with ICAO Doc 8071 VOL 2 to confirm ability of the GAST-D Ground Subsystem to support GBAS CAT III operations

See also A#0071. See also Error! Reference source not found.</td><td>Flight Inspection → Maintenance /12(GBAS Signal Verif)</td></tr>
<tr><td>SR 210: GAST-D Ground Subsystem siting shall be carried out in accordance with EUROCAE ED 114 as amended by 15.3.6 D4 requirements (Ground architecture and airport installation)</td><td>GAST-D Ground Subsystem</td></tr>
<tr><td>See SR 175, SR 180 and SR 185 above</td><td>See elements applicable to SO#0050 above</td></tr>
</table></td></tr>
<tr><td>41</td><td>2.8.2 Table 4</td><td>Table 4 row 2 shall be as follows:
<table>
<tr><td>2</td><td>Unintentional Interference (impacting GNSS and/or VDB)

→specific to GBAS</td><td>The aircraft might loss the GBAS guidance (continuity event) during the approach when encountering the interference</td><td>Note that loss of continuity is considered the main effect of unintentional RFI. However, this relies on the assumption that the ground station is appropriately designed in accordance with ED-114B 3.1.6 “Integrity in the Presence of Excessive Radio Frequency Interference”.

Preventive Mitigations:

a) The proposal for mitigating the effects of the interference should rely on a combination of:
Siting restriction on the ground subsystem
State spectrum regulation, frequency management</td></tr>
</table></td></tr>
</table>

					and enforcement of these regulation • Specific maintenance procedure as a prerequisite • Making the GBAS Ground Station, as well as airborne GNSS receivers robust against interference, See **Error! Reference source not found.**, **Error! Reference source not found.** and **Error! Reference source not found.** • Above preventive mitigations will be captured in SAR section **Error! Reference source not found.** b) For GBAS CAT III approach and landing: → Aircraft respects the lateral and vertical path of the published GBAS approach when interference signals are encountered or aircraft executes a safe go-around (SO#0315/ SAC#01) →Aircraft lands in the prescribed touch down zone when interference signals are encountered or aircraft executes a safe go-around (SO#0320/ SAC#04) → Successful Aircraft GBAS landing rollout when interference signals are encountered or aircraft executes a safe go-around (SO#0325/ SAC#04) c) For GBAS guided Take-Off: → Aircraft respects the lateral path for the guided take-off from the start of the take-off roll to the main wheel lift-off when interference signals are encountered or aircraft aborts safely the take-off. (SO#0405/ SAC#04). Corrective Mitigations: → Aircraft executes a missed approach in case of loss of GBAS continuity during a GBAS CAT III approach. The

<table>
<tr><td></td><td></td><td>
<table>
<tr><td></td><td></td><td></td><td>missed approach can be executed with the autopilot still engaged or manually. (SO#330/ SAC#01 and SAC#04).

→ Aircraft aborts the guided take-off in LVC in case of loss of GBAS continuity and impossibility to continue to monitor external visual cues (centerline lights) (SO#410/ SAC#04).</td></tr>
</table>
</td></tr>
<tr><td>92</td><td>3.4.2.1.

Table 21</td><td>Table 21: the rows related to #1 Severe Ionospheric disturbances shall be as follows:
<table>
<tr><th>Preventive mitigations for abnormal conditions</th><th>Safety Requirements for abnormal conditions</th></tr>
<tr><td colspan="2">#1 Severe Ionospheric disturbances</td></tr>
<tr><td rowspan="3">Monitoring in the ground subsystem</td><td>See SR200 (includes provisions on iono gradient monitors).</td></tr>
<tr><td>REC#0020: Depending on ionospheric conditions, the risk of exposure to scintillations should be taken into account in the monitor design</td></tr>
<tr><td>A#0240: North of N40˚ in the ECAC zone, severe ionospheric gradients can be assumed to occur with a probability of less than 1E-05. Between N40˚ and N26˚ in the ECAC zone, severe ionospheric gradients can be assumed to occur with a probability of less than 1E-04.

Note: GAST D iono gradient monitoring is built upon assumptions about the frequency of occurrence of such phenomena. This “prior probability” may be different from one geographic region to another, but at least a worst-case assumption should be captured in operational safety assessments so that the ANSP may correlate it with local space weather measurements.</td></tr>
<tr><td>Monitoring in the airborne segment</td><td>See SR175 (includes provisions on airborne mitigation of iono anomalies).</td></tr>
<tr><td>Siting restriction on the ground subsystem</td><td>SR 500: The GAST-D Ground Station siting requirements shall include measures taking into account the effect of ionospheric disturbances.

Technical traceability/comments:
a. A GAST D ground subsystem shall transmit parameters MEIG and YEIG overbounding the worst case residual ionospheric range error decorrelating with distance, up to a distance specified as the maximum distance at which the specific ground subsystem can serve CAT III LTPs. The Ground Subsystem monitor design shall be optimized, targeting a maximum EIG (residual ionospheric range error) of 2.75 m 5 km from the ground facility.
b. Antenna separations shall be determined based on risk of correlated multipath, and the selected Ionospheric gradient monitoring scheme. (from 15.03.06 D04 Siting Consideration Req [Iono2] and 15.3.6 GAST D Conops S7).</td></tr>
</table>
</td></tr>
</table>

			c. Depending on selected ionospheric gradient monitoring scheme, the effective baselines shall be perpendicular to the worst-case wave front and thus, in order to detect gradients from all directions, must have projected baselines both aligned with, and perpendicular to, CAT III runways (from 15.03.06 D04 Req [Iono3]).
			REC#0021: The stability of the antenna foundation should be considered with respect to the selected ionospheric gradient monitoring scheme.
			SR#503: The ANSP siting procedures shall include an analysis of distance of the GBAS reference point from threshold to verify that the ionospheric threat is mitigated.
		A standard threat space which defines the range of ionospheric anomalies to which the user will be exposed	REC#0022: MET and AIS providers should undertake specific studies in order to assess the feasibility of space weather forecast integration into the NOTAM system or by providing directly to end-users "Extreme Space weather" alerts, to prevent usage of GBAS for Cat III operations in case of very large ionospheric storm.
		Local ionospheric threat space assessment by ANSP	REC#034: It is recommended that a worst-case assumption on the frequency of iono gradients be defined by the GS manufacturer in order to permit local correlations by ANSPs
			SR#502: ANSPs shall perform local assessments on each GAST D implementation scenario to define the conditions under which the ECAC ionospheric threat space is realistic.
			SR#455: If the Ground Subsystem monitoring concept for ionospheric monitoring makes assumptions on the tropospheric threat space, the ANSP shall perform a local assessment to establish a tropospheric characterization
95	3.4.2.1 Table 21	Table 21: the rows related to Updated maintenance procedures under #2 Unintentional Interference (impacting GNSS and/or VDB)	
		Updated maintenance procedures	SR 525 If interference is confirmed, maintenance procedures shall ensure that the approach procedure be removed from operational status pending corrective action and appropriate authorities notified. Maintenance task levels A/B shall be assigned depending on the impact of the interference over the continuity and/or integrity of the service performance of the Ground Subsystem.
			SR 530: Airport maintenance procedures shall include the creation (if needed), or the maintenance and repairing (if they exist) of fencing/ barriers designed to block/dampen interfering signals
			SR 531: If interference is suspected, maintenance procedures shall define the conditions of investigation efforts and pre-commissioning surveys of the interference environment. Maintenance task levels A/B shall be assigned depending on the impact of the interference over the continuity and/or integrity of the service performance of the Ground Subsystem. Note: The suspected area should be probed, and spectrum analysis accomplished to define its geographical extent; GNSS and GBAS parameters such as signal/noise ratio, lateral and vertical protection levels, and DOP should be documented.
			REC#028: Airport maintenance procedures should include the development of additional mitigation methods, such as barrier construction or reference receiver relocation, in case interference sources cannot be removed.
167	4	Conclusion	

		This document contains the Specimen Safety Assessment for a typical application of the OFA01.01.01 (LVPs using GBAS) relative to GBAS CAT II-III operations based on single GPS frequency (L1) known as GAST-D (GBAS Approach Service Type D). The applicable Operational Improvement is AO-0505-A. Furthermore, this document includes a dedicated appendix on security considerations. This operational safety assessment addresses both CAT III approach & landing operations and Guided Take-Off in Low Visibility Conditions. This assessment was conducted considering the operational change (optimised operations) described in the GBAS CAT II/III Functional Description update Report/OSED (06.08.05 D47) and the technical change described in the GBAS CONOPS including CAT II/III specificities (15.03.06 D20). This operational safety assessment does not address specifically GBAS CAT II approach operations because there is no ICAO GAST-D requirements specific to CAT II. Furthermore, GBAS CAT III approach and landing operations are considered to be more challenging and demanding than CAT II operations. This operational safety assessment started by the identification of Safety Criteria describing what is acceptably safe for the operational concept supported by GAST-D. Then Safety Objectives were derived at operational level (OSED) to satisfy the Safety criteria in normal, abnormal and failure conditions. Finally, when the high-level design architecture supporting the operational level was defined, Safety Requirements in normal/abnormal conditions and considering failure aspects were derived to satisfy the Safety Objectives. Safety Requirements were determined though the success and the failure approach as described by the SESAR Safety reference Material (SRM) developed by Project 16.06.01. During this iterative process, safety validation objectives have been identified and have been addressed during different Validation Exercises which are of different nature: • Validation exercise addressing the operational aspect (optimised operation) and managed by Project 06.08.05 • Validation exercises addressing the technical change (GAST-D) and managed by Project 15.03.06 which have been conducted through two successive validation phases (Phases 1 to 2). A last verification phase (Phase 3) was conducted[1] • Furthermore, validation focusing on the GAST-D airborne side have been conducted by Project 09.12 The report presents the assurance that the Safety Requirements for the V1-V3 phases are complete, correct and realistic. Furthermore, assumptions, issues, recommendations and limitations have been identified during the safety assessment. • The main assumption which is not yet validated is relative to the GBAS CAT III obstacle clearance. This assumption should be validated at ICAO level (IFPP) to confirm that GBAS CAT III obstacle clearance is identical to ILS CAT III. • Several safety issues remain open and the main ones are relative to: o The phraseology to be used during GBAS operation (GBAS or GLS) This issue should be addressed at ICAO level. o The interference impact of GNSS repeater on aircraft receivers leading to position error. This was identified during verification tests and this needs to be investigated with possibly the definition of additional requirements within the frame of SESAR 2020 o For the multiple VDB concept, the current VDB authentication protocol requirements and assumptions as well as requirements for airborne GBAS VDB receivers do not support multi VDB implementations with path diversity. The message failure rate at airborne level shall remain at an acceptable level and this aspect must be verified.in future activities (SESAR 2020).

[1] This updated Safety report includes the results of the latest 15.03.06 verification phase (Phase 3)

		• Several recommendations remain open in particular the one associated to naming and phraseology used for GBAS which recommends consistency between radiotelephony communications, charting information, ATC displayed information and flight deck indication. • The main outstanding limitation, not finally addressed and concluded within the scope of the SESAR R&D projects, is the suitability of CAT II only aircraft for GAST D which was not fully shown in SESAR 1 and which needs to be addressed by SESAR 2020.

-END OF DOCUMENT-